

# UNCLASSIFIED

AD NUMBER
AD463752
NEW LIMITATION CHANGE
TO Approved for public release, distribution unlimited
FROM Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; 13 MAY 1965. Other requests shall be referred to Office of Naval Research, 875 North Randolph St., Arlington, VA 22203-1995.
AUTHORITY
ONR ltr, 9 Nov 1977

THIS PAGE IS UNCLASSIFIED

UNCLASSIFIED

AD-4 63752

DEFENSE DOCUMENTATION CENTER

FOR

SCIENTIFIC AND TECHNICAL INFORMATION

CAMERON STATION ALEXANDRIA, VIRGINIA



UNCLASSIFIED

NOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

4 6 3 7 5 2

CATALOGED BY: DDC

AS AD NO.

463752

Observations  
of the  
**OWENS VALLEY RADIO OBSERVATORY**

California Institute of Technology  
Pasadena, California

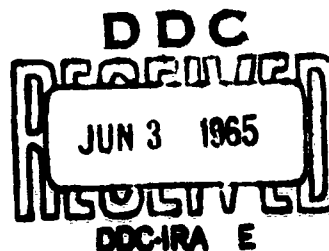
1965

AVAILABLE COPY WILL NOT PERMIT  
FULLY LEGIBLE REPRODUCTION.  
REPRODUCTION WILL BE MADE IF  
REQUESTED BY USERS OF DDC.

7. TIME DEPENDENCE OF THE RADIO EMISSION  
FROM CTA 21 AND CTA 102

by

P. Maltby and A. T. Moffet



TIME DEPENDENCE OF THE RADIO EMISSION  
FROM CTA 21 AND CTA 102

by

P. Maltby\* and A. T. Moffet

Sholomitskii (1965) has recently presented evidence for changes in the radio emission from the source CTA 102. Sholomitskii finds that his observed intensities at a wavelength of 32.5 cm may be fitted to a sinusoidal law with a period of about 100 days and an amplitude of  $\pm 23\%$ . His result is based on a comparison of the flux densities of CTA 21 and CTA 102 with that of 3C 48, apparently on nine days within the period August, 1964, to February, 1965.

Since their discovery in 1959 (Harris and Roberts 1960), the radio sources CTA 21 and CTA 102 have been studied fairly extensively at this observatory. In particular, we carried out two series of brightness distribution measurements (Moffet 1962; Maltby 1962) during 1960 and early 1961 at a wavelength of 31.3 cm, very close to that used by Sholomitskii. An additional group of observations at this wavelength were made in September, 1961, by Kellermann (1964). In this paper we will restrict our discussion to these 31.3-cm observations. We will show that in 1960 no intensity variation was present having the amplitude and period reported by Sholomitskii.

The 31.3-cm observations of CTA 21 and CTA 102 are summarized in Table 1. The 1959 observations were made with a Dicke radiometer on one 90-ft antenna. All subsequent observations were made with two 90-ft antennas connected as an interferometer. The interferometer has been described in detail by Read (1961, 1963). Recent high-resolution interferometric studies (Anderson, Donaldson, Palmer, and Rowson 1965) have shown that both CTA 21 and CTA 102 have angular diameters of less than  $0''.4$ . This means these sources are not at all resolved by any interferometer spacing used in the Caltech observations; thus each of our observations gives a measure of the total flux from these sources.

In order to look for possible variations in the intensity of a particular radio source, it is necessary to correct for variations in receiver gain and other instrumental factors. The calibration procedures for the Caltech observations have been discussed in the papers cited above. In general, a number of small-diameter sources are used as standards for each day's observations.

The fluxes in Table 1 are on Kellermann's intensity scale, which is about 3.5% lower than that used by Harris and Roberts and by Moffet and Maltby. Fig. 1 shows the fluxes plotted versus time. For comparison we have included in Fig. 1 Sholomitskii's measurements in 1964 and

---

\* On leave of absence from the Institute of Theoretical Astrophysics, Oslo, Norway.

1965, which are copied from the figure accompanying his note. These have been converted to fluxes by assuming an intensity of  $21.0 \times 10^{-26} \text{ W m}^{-2}(\text{c/s})^{-1}$  for 3C 48. The dashed curve is the sinusoidal intensity variation suggested by Sholomitskii for CTA 102.

Most of the points for our observations represent averages over several days, as is indicated in Table 1. Except for the single-dish observations of 1959, the greatest span of time represented by a single point is 13 days. If the individual observations were plotted, the scatter would be about the same as the scatter among the points representing the averages at different interferometer spacings.

As is seen in Fig. 1, our observations show the flux density of CTA 102 to be constant to within  $\pm 4\%$  of the mean, while the observations of CTA 21 are constant to within  $\pm 8\%$ . The difference between these two figures is not significant, and we conclude that no variation with an amplitude as great as  $\pm 10\%$  was present during the periods of our observations. The two series of observations at the beginning and end of 1960 cover spans of 60 to 90 days. They would have been quite sensitive to variations with a period of about 100 days, as reported by Sholomitskii. However, the four different series of Caltech observations happened to come at intervals of about 8 months. Thus we would be less sensitive to intensity fluctuations with periods of about 240 or 480 days. It might also be argued that variations in the intensity of CTA 102 commenced after 1961, although this seems to us rather unlikely.

It is difficult to account for the discrepancy between Sholomitskii's and our observations. Sholomitskii states that the variations he observed were "far in excess of the errors of measurement." In an earlier paper Sholomitskii, Kuril'chik, Matveenko and Khromov (1964) report measurements of other radio sources at 32 cm, presumably made with the same instrument. Flux errors for measurements reported in that paper range from  $\pm 0.25$  to  $\pm 1.0$  flux units. The maximum range in flux reported by Sholomitskii for CTA 102 is 2.3 flux units. Thus the range of variation is not much larger than the greatest errors quoted by Sholomitskii et al. Sholomitskii et al report some of the details of their radiometer, but the characteristics of the antenna they used have not yet appeared in the literature. Until the characteristics of this antenna are published, it is difficult to evaluate any observations made with it. To cite one specific example, it is impossible to judge the effect of solar radiation entering the antenna sidelobes when no information has been published about the reception pattern of the antenna.

Sandage and Wyndham (1965) have identified CTA 102 with a quasi-stellar object. If CTA 102 has a radio luminosity equal to that of other objects in this class, it is possible to calculate a minimum diameter for the source region. The observed radio spectrum requires that the source be optically thin for frequencies above  $10^3 \text{ Mc/s}$ . Cutoff frequencies for synchrotron self-absorption, free-free absorption and the Tsytovich effect (see Scheuer 1965 for a review of these mechanisms) must be less than this value. If we assume that the density of thermal electrons is  $\leq 10^2 \text{ cm}^{-3}$  and the magnetic field is in the range  $10^{-2}$  to  $10^{-4}$  oersted, then the minimum size is about 100 pc.

Sholomitskii has pointed out that an intensity variation with a period of 100 days requires a source diameter of 0.1 pc or less. A detailed consideration of the problem of variation in radio sources is beyond the scope of this paper. If the radio emission from quasi-stellar objects does show short-period variations, our present concept of these objects must be revised; in particular, their large redshifts must then be of other than cosmological origin.

This work was supported by the U. S. Office of Naval Research under Contract Nonr 220(19).

#### References

- Anderson, B., Donaldson, W., Palmer, H. P., and Rowson, B. 1965, *Nature*, 205, 375.
- Harris, D. E., and Roberts, J. A. 1960, *Pub. A.S.P.*, 72, 237.
- Kellermann, K. I. 1964, *A.J.*, 69, 205.
- Maltby, P. 1962, *Ap. J. Suppl.*, 7, 124.
- Moffet, A. T. 1962, *Ap. J. Suppl.*, 7, 93.
- Read, R. B. 1961, *Trans. I.R.E.*, AP-9, p. 31.
- \_\_\_\_\_ 1963, *Ap. J.*, 138, 1.
- Sandage, A. R., and Wyndham, J. D. 1965, *Ap. J.*, 141, 328.
- Scheuer, P. A. G. 1965, Quasi-Stellar Sources and Gravitational Collapse, ed. I. Robinson, A. Schild, and E. L. Schucking (University of Chicago Press), p. 373.
- Sholomitskii, G. B. 1965, Inform. Bull. on Var. Stars, Comm. 27 of the I.A.U., No. 83.
- Sholomitskii, G. B., Kuril'chik, V. N., Matveenko, L. I., and Khromov, G. S. 1965, *Astr. Zhur.*, 41, 823 (trans. *Soviet Astr.-A.J.*, 8, 660).

Table 1  
FLUX DENSITIES OF CTA 21 and CTA 102 AT 31.3 CM

Date	Spacing	CTA 21		CTA 102	
		Flux Density [ $10^{-26} W_m^{-2} (c/s)^{-1}$ ]	No. of Observations	Flux Density [ $10^{-26} W_m^{-2} (c/s)^{-1}$ ]	No. of Observations
1959 Aug-Nov	0	8.7 ± 1.0	4	7.0 ± 0.6	3
1960 Feb 25-29	195λ EW	8.1 ± 0.9	2	...	...
March 3-4	126λ EW	8.1 ± 1.1	1	...	...
April 5-8	292λ EW	8.4 ± 1.1	1	7.1 ± 0.8	1
April 29-30	779λ EW	...	...	7.5 ± 0.9	1
May 14-19	1557λ EW	...	...	7.5 ± 0.8	4
May 21-22	1168λ EW	8.3 ± 1.1	1	...	...
May 27-28	973λ EW	8.6 ± 1.2	1	...	...
1960 Nov 29-Dec 12	172λ NS	...	...	7.6 ± 0.3	5
Dec 3-6	178λ NS	9.5 ± 0.6	3	...	...
1961 Jan 3-9	356λ NS	9.0 ± 0.3	4	...	...
Jan 5-15	344λ NS	...	...	7.3 ± 0.3	3
Jan 19-22	688λ NS	...	...	7.4 ± 0.4	3
Jan 20-24	712λ NS	8.7 ± 0.3	3	...	...
Feb 10-12	1424λ NS	8.9 ± 0.4	2	...	...
Feb 10-12	1376λ NS	...	...	7.0 ± 0.4	2
1961 Aug 30-Sep 4	98λ EW	9.2 ± 0.3	2	7.2 ± 0.3	3



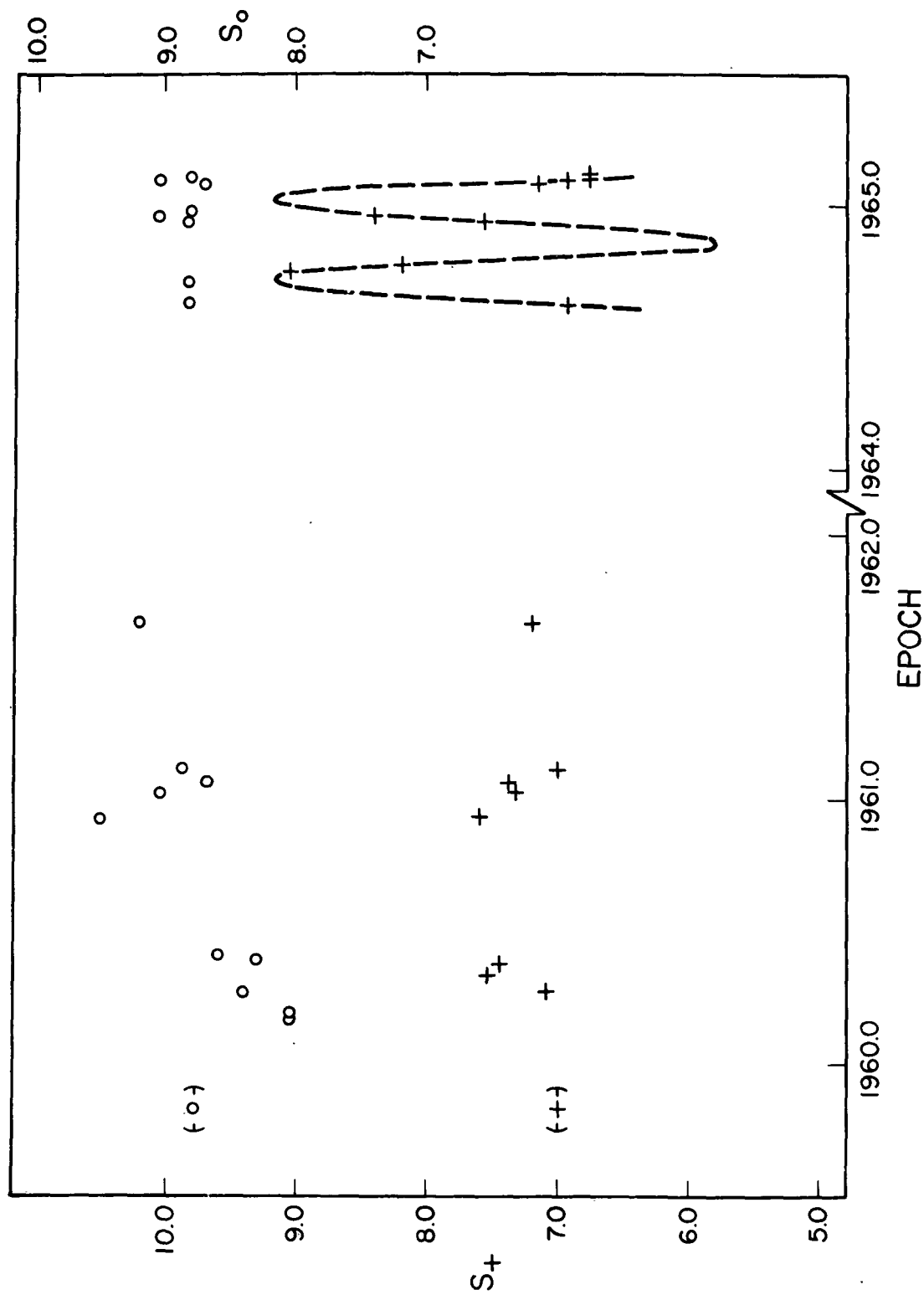


Figure 1. Measured intensities of CTA 102 (crosses and intensity scale on left) and of CTA 21 (circles and scale on right). For comparison we have plotted on the right the data and suggested light curve of Sholomitskii (1965). Units are  $10^{-26} \text{ W m}^{-2} (\text{c/s})^{-1}$ .

## DOCUMENT CONTROL DATA - R&amp;D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) <b>Owens Valley Radio Observatory California Institute of Technology Pasadena, California 91109</b>		2a. REPORT SECURITY CLASSIFICATION <b>U</b>	
		2b. GROUP	
3. REPORT TITLE <b>Time Dependence of the Radio Emission from CTA 21 and CTA 102.</b>			
4. DESCRIPTIVE NOTES (Type of report and inclusive dates)			
5. AUTHOR(S) (Last name, first name, initial) <b>Maltby, P., and Moffet, A. T.</b>			
6. REPORT DATE <b>13 May, 1965</b>		7a. TOTAL NO. OF PAGES <b>5</b>	7b. NO. OF REFS <b>11</b>
8a. CONTRACT OR GRANT NO. <b>Nonr 220(19)</b>		9a. ORIGINATOR'S REPORT NUMBER(S) <b>No. 7, 1965</b>	
b. PROJECT NO.		9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	
c.			
d.			
10. AVAILABILITY/LIMITATION NOTICES <b>Qualified requesters may obtain copies of this report from the Owens Valley Radio Observatory.</b>			
11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY <b>U. S. Office of Naval Research</b>	
13. ABSTRACT  <b>Sholomitskii has reported variations with a period of about 100 days and amplitude of <math>\pm 23\%</math> in the 32.5 cm radio intensity of CTA 102. We have examined the Caltech observations of this source at 31.3 cm, which cover the period from its discovery in 1959 through 1961. A firm upper limit of <math>\pm 10\%</math> can be set on variations with 100 day period.</b>			